ROZZI, LOUISE MARIA. A Cinematographic Analysis of the Lacrosse Cradle. (1969) Directed by: Dr. Frank Pleasants. pp. 52

The purpose of this study was to investigate the lacrosse cradle through cinematographic analysis. The investigation included an analysis of joint angles throughout the execution of the skill and a close examination of the position of the crosse with relation to the body and the ground.

The skill was executed by two individuals of differing experience in the game of lacrosse. One was a beginner who had completed a semester of a beginning lacrosse activity class but had not competed at the varsity level. The other subject was an experienced player who had participated competitively in the game of lacrosse. The skill performance of both subjects was analyzed and dominant distinctions in execution were noted. Analysis was, in some instances, facilitated by comparing the subjects' execution of the skill but comparison was not a primary purpose.

Two 16mm Bolex movie cameras remained fixed and focused on the filming area. The subjects then began to cradle, one at a time, into the field of vision and toward the cameras. The subjects were directed to maintain their run between vertical standards and relatively close to a line so that any additional perspective errors were eliminated. The skill was performed five times by each subject.

Generally, the cinematographic analysis of the skill performance of the two subjects proved to be in accordance with the opinions of experts. The major distinctions between opinion and

performance was found to be in the position of the forearm in relation to the ground and the waist of the subjects and the position of the crosse to the ground.

Although the beginner and the experienced player flexed and extended their wrists in accordance with the expert descriptions, the experienced player demonstrated a greater range of motion in the joints. Finally, the measurements obtained from the film with regard to body rotation revealed that the beginner did not move her body from the forward position to any great degree. More rotation was measured from the film taken of the experienced player.

A CINEMATOGRAPHIC ANALYSIS OF THE LACROSSE CRADLE

by

Louise Maria Rozzi

A Thesis Submitted to
the Faculty of the Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Master of Science in Physical Education

Greensboro
August, 1969

Approved by

Thesis Adviser

APPROVAL SHEET

This thesis has been approved by the following committee of the Faculty of the Graduate School at The University of North Carolina at Greensboro.

Thesis Adviser Mark Blanarte

Oral Examination
Committee Members Marion K. Sollenberger

Rosemary McGee

Paul E. Lutz

August 21, 1969
Date of Examination

ACKNOWLEDGMENTS

The author wishes to express her sincere appreciation to her adviser, Dr. Frank Pleasants, for his guidance and encouragement.

The author also wishes to express her gratitude to Mr. Emil Young for his expert advice and assistance during the filming section of the study.

Nancy Blum and Judy Smith were the subjects in the study. The author extends her thanks to these girls for their patience and cooperation.

Andrea Farrow, Karla Johnston and Bette Ann LeFort deserve special recognition for their assistance and inspiration throughout the study.

TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

LIST OF FIGURES

FIGURE PAGE

CHAPTER I

INTRODUCTION

Lacrosse is a game of "exceptional skill, grace," and endurance. (1:21) Its unfamiliar movement patterns afford the student of lacrosse much difficulty in executing the cradle.

Several books have been written about the game and skills of lacrosse which include descriptions of the "proper" execution of the skills. However, the author found no previous attempts to cinematographically analyze any of the skills in order to verify or rectify the descriptions.

The author believed that such an analysis of the lacrosse cradle could reveal cues which may assist the teacher in the instruction of this skill and the student in the learning of the skill.

Statement of the Problem

The purpose of this study was to investigate the lacrosse cradle through cinematographic analysis. The investigation included an analysis of joint angles throughout the execution of the skill and a close examination of the position of the crosse with relation to the body and the ground. The skill was executed by two individuals of differing experience in the game of lacrosse. One was a beginning player; the other was an experienced player. The skill performance of both subjects was analyzed and dominant

distinctions in execution were noted. Analysis was, in some instances, facilitated by comparing the subjects' execution of the skill, but comparison was not a primary purpose of this study.

Definitions

Beginning Player

The individual who had completed a semester of a beginning lacrosse activity class and had not competed on a varsity level in the game of lacrosse met the criterion of a beginner.

Experienced Player

The individual who had participated competitively in the game of lacrosse was classified as being experienced.

Crosse or Stick

That piece of equipment used to carry and throw the lacrosse ball.

Cinematographic Analysis

This method was explained by Cureton in the following statement:

> . . . analysis of the external mechanics of many acts of skill may be made by cinematography. The fundamental principle is that directions of movement (angles), dimensions, time relations, and indirect values of force and velocity may all be obtained from the projected film. Cinematographic analysis consists of the technique for making these measurements. (7:5)

Frame

One of a series of many segments on a roll of movie film. That portion of the film which reveals one picture.

Complete Run

This refers to the performance of the skill which occurred from the time the subject stepped on or over the starting line to the time she stepped on or over the finish line, a total of twenty feet.

Sequence

That section of the complete run which includes one single cradling action and all the frames that picture it.

Measurement Frames

The subject stands beside an object of known length in the filming area. The known length is used to calculate a conversion factor. The conversion factor is used to change the projected height or length of an object or subject to its actual size. Measurement frames are also used to obtain the actual speed of the camera. This is accomplished by dropping an object a known distance and making the necessary calculations. These frames are taken before, and/or during, and/or after the actual filming. Both factors, size and speed, are essential for proper analysis.

Delimitations

1. The study was delimited to two subjects due to the lack of accessibility of both beginning and experienced lacrosse players.
2. It was assumed that the camera speed remained constant.
3. The study was also delimited to a contrived skill performance as opposed to an actual game performance of the

skill. It was necessary to simulate the situation in order to cinematographically analyze the performance of the skill.

CHAPTER II

REVIEW OF LITERATURE

History and Development of Lacrosse

Although the game of lacrosse is generally associated with countries of Europe, literature reveals that it is in fact native to North America. This statement has been challenged recently by investigations which indicate that Norsemen played a game called Knattleikr in Iceland in 874. (1:14) Knattleikr had been compared to lacrosse by a Professor Ebbe Keitzberg, who believes that the basic fundamentals of the game are closely associated. Thus, he states that the Norsemen introduced this game to the Indian tribes of the Northeastern coast of America and from there spread inland. (1:14)

While these claims cannot be accepted as certain, the North American Indian origin of the game has been substantiated by eye witness accounts and is beyond dispute. (1, 3, 4, 6) There are records of travelers to North America in the eighteenth century which reveal that Indian tribes were playing a well-established game. (1:15)

The original game was a combination of a sport and a deadly combat. Players often suffered serious injury and even death. Its original intent was to serve as a game for amusement,

yet it developed into an activity which served as a training time for young warriors. (4:3)

The contest, played between tribes, was preceded by two weeks of vigorous training. On the night before, there were rituals to the Great Spirit. (4:5) The match usually began in the morning. Indian maidens ran forward and bedecked the players with beads and other tokens of affection. (4:4) The game started either with a high toss of the ball into the air with players scrambling for it as it fell to the ground or it was placed on the ground with all the players scrambling for it on a given signal. (4:4)

The earliest stick used was about three feet in length with one end bent into an oblong or round loop large enough to hold the ball. (4:4) Some carried two sticks. (1:14) It was played on a field of over several miles and the score usually reached one hundred points. (1:14) The Indians called it Baggataway. (6:469)

Pierre Francois Zavier de Charlevoix, a famous historian, saw the Algonquin Indians in a game. The stick that this tribe used was in the form of a "crook across which thongs had been drawn to form a pocket." (1:15) Since this reminded him of a crozier or pastoral staff used by a bishop, he called it the game of the "crozier - la cross." (1:15) This was in 1705 and from it the contracted form of the term, "lacrosse," is used. (1:15)

The first white people to become interested in the game were the French Canadians. Their involvement and enthusiasm enabled lacrosse to become the national game of Canada in 1867. This is also the year that the first rules were constructed. (1:15)

England witnessed the game in 1876, when the French and Indians played demonstration games before Queen Victoria at Windsor. The gentlemen of that country have been playing lacrosse since that time. (1:16)

It is suspected that the first girl played lacrosse as early as 1886 at the Ladybarn House School, Manchester, England. The headmistress thought the game of lacrosse appropriate for boys and girls to participate in together. (1:16)

When the game first began to be played in an organized form, the teams were arranged with eight on a side and listed as forwards and backs. In 1897 there were ten on a side, and in 1899 there were twelve as it is played today. (1:17)

The English women modified the rules to eliminate the roughness and contact of the men's game. (3:1) The first club formed was the Southern Ladies' in 1905, and in 1912 the Ladies Lacrosse Association was founded. This is the official body to which schools, clubs, and colleges affiliate. (1:17)

The United States Women's Lacrosse Association was founded in 1931 and controls the affairs of their game. (1:18) In 1933, the first National Tournament in the United States was played on Greenwich Academy fields and has become an annual event. (3:1) The English women were invited to visit the United States in 1934. This furthered the enthusiasm and learning progressed. The following year sixteen American players toured England, Ireland and Wales to play and study lacrosse. (3:1)

Today lacrosse is played and taught in schools and colleges throughout the United States. Lacrosse Association teams have been formed throughout the country and culminate their season at the annual National Lacrosse Tournament.

Cradling

The Grip

For right-handed individuals, the right hand is normally on the top of the stick at the collar. When the stick is facing the player with the backbone to the right of the individual, the "V" formed by the thumb and forefinger is between the player's face and the stick when held vertically. The knuckles are underneath the stick, and the thumb and forefinger meet. With the stick held perpendicular to the ground and the "V" of the thumb and forefinger pointing directly to the crosse head, the left hand reaches forward to grasp the butt end firmly in the entire hand. (1, 6)

The Cradle

Margaret Boyd, author of Lacrosse Playing and Coaching, defines cradling as". . . the name given to the rhythmical swinging movement of the stick, timed to fit the running action of the player and designed to keep the ball in the crosse." (1:31) In the text, Individual and Team Sports for Girls and Women, Vannier and Poindexter define the cradle as ". . . the rhythmical swing of the stick timed to the action of the player's body, that keeps

the ball under control and in the crosse." (6:476) Thus, there are two factors which are emphasized in these definitions and are critical to the cradling skill. They are the "rhythmical swinging action" and the necessity to "keep the ball in the crosse."

Once the player has gripped the crosse, it is in a vertical position in front of the body. (1, 3, 5, 6) Boyd explains that the bottom hand is approximately at waist level and should not be allowed to fall below the waist in any of the cradling movements. (1:30) Both hands move in the same direction in a circular arc from one side of the body to the other. (1, 3, 5, 6)

Although neither the textbook nor the specialized lacrosse books describe the skill in specific sections, the author has separated the entire movement into two parts in order to facilitate analysis.

Swing to the Right

The bottom hand (left hand) is swung to the right, so that it wraps around and remains close to the waist. (1, 6) The left wrist flexes toward the body to complete the swing. (1, 6)

The forearm of the top hand (right hand) remains as close to the back of the stick as possible. There is also slight extension of the wrist at the end of the swing. (1, 6) The flexion and extension of the wrists allow the crosse to move over a greater distance.

The left knee bends inward; the left heel is off the ground; the right knee is relaxed. (5:103)

Swing to the Left

It is essential that both arms work together to swing the stick in a vertical position to the left. (1, 4, 5)

The left forearm remains parallel to the ground and at waist level as it swings out, away from the body and to the left. (1, 4, 5) Margaret Boyd clearly describes this action by stating:

> It is in fact pivoting on the elbow which remains relaxed close to the side of the body, but not tucked in or resting on the hip bone. (1:31)

The top hand (right hand) guides the stick in front of the body with the wrist flexing as much as possible at the end of the swing. (1, 4)

The right knee bends inward; the right heel is off the ground; the left knee is relaxed. (6:103) Rotation of the body at the waist in the direction of the swing is important to the complete cradling movement. (1, 5) This trunk movement also aids in allowing the crosse to move over a greater distance.

Comments

The run and cradle are combined in a type of symmetrical pattern. More explicitly, when the player steps on her left foot, the crosse is swung to the left side as she does so and then to the right as she swings to the right. The faster the run the faster the swinging motion or cradle. (1, 5)

Essentially, the movement of the stick from side to side is executed by the bottom hand. The top hand acts as a guide and assumes the weight of the crosse. (1:31-32) The flexing and

extending of both wrists, especially of the bottom hand, turns the crosse so that the guard of the stick is nearest the player when it is swung to the left and the head of the crosse is nearest the player when it is swung to the right. (1:31) This twisting of the stick allows the ball to remain in the crosse which is the objective of the total movement pattern. (1, 3, 5, 6)

After reviewing the literature pertaining to the skill of lacrosse, it was evident that the only available analysis was based on observation and presented in a descriptive manner. No mechanical analysis or cinematographic analysis of any lacrosse skill was found. However, many specifics of the skill were mentioned but by individuals employing the observational method of skill analysis. The author believes that more research of a biomechanical nature might validate or rectify the analysis.

CHAPTER III

PROCEDURES

A film was made previous to the final film in order to study appropriate placement of cameras and to decide the number of cameras needed.

Photography Technique

Equipment

There were two 16mm Bolex movie cameras, two 25mm lenses, two tripods, and four vertical reference points.

Location

The filming took place outside on the athletic field of The University of North Carolina at Greensboro. Trial runs were conducted to be sure that the subjects were in view of the cameras throughout the skill performance.

Cameras

The two 16mm Bolex movie cameras were each equipped with a 25mm lens. They were set to record at 64 frames per second. The film used was negative type 7231, PXN 440. Negative film was used because it is more practical for motion study. It also facilitates processing of film for photographic enlargements.

In order to film the skill and record the changing body angles and rotations, the cameras were set at 45 degree angles. The cameras were sixty feet from the center of the filming area.

They were set on tripods and measured four feet eight inches from the ground to the bottom of the lens. The distance and height were established after the cameras were focused on the filming area. At this distance and height, the cameras remained fixed and focused on the filming area. The 25mm lens presented the least amount of distortion at this range. Figure 1 shows a diagram of the filming situation.

Measurement Frames

Two measurement frames were taken to establish size. A subject stood facing one camera with a yardstick held beside her. One frame was taken preceding the actual filming and another toward the middle of the film as a counter check. Both frames were taken at point B on Figure 1. This location was the exact mid-point of the filming area.

Several measurement frames for speed were taken at the conclusion of the actual film. These frames were recorded in order to establish the actual speed of each camera. To accomplish this, a shot was dropped several times and calculations were made. A volleyball standard was placed at point B. This standard was marked with tape at a point 72 inches from the ground. The shot was held above the 72 inch mark and was dropped. The formula $S = \frac{1}{2}gt^2$ was used.

S = distance object fell
g = 32.2 feet/second^2
(acceleration due to gravity)
t = time in seconds

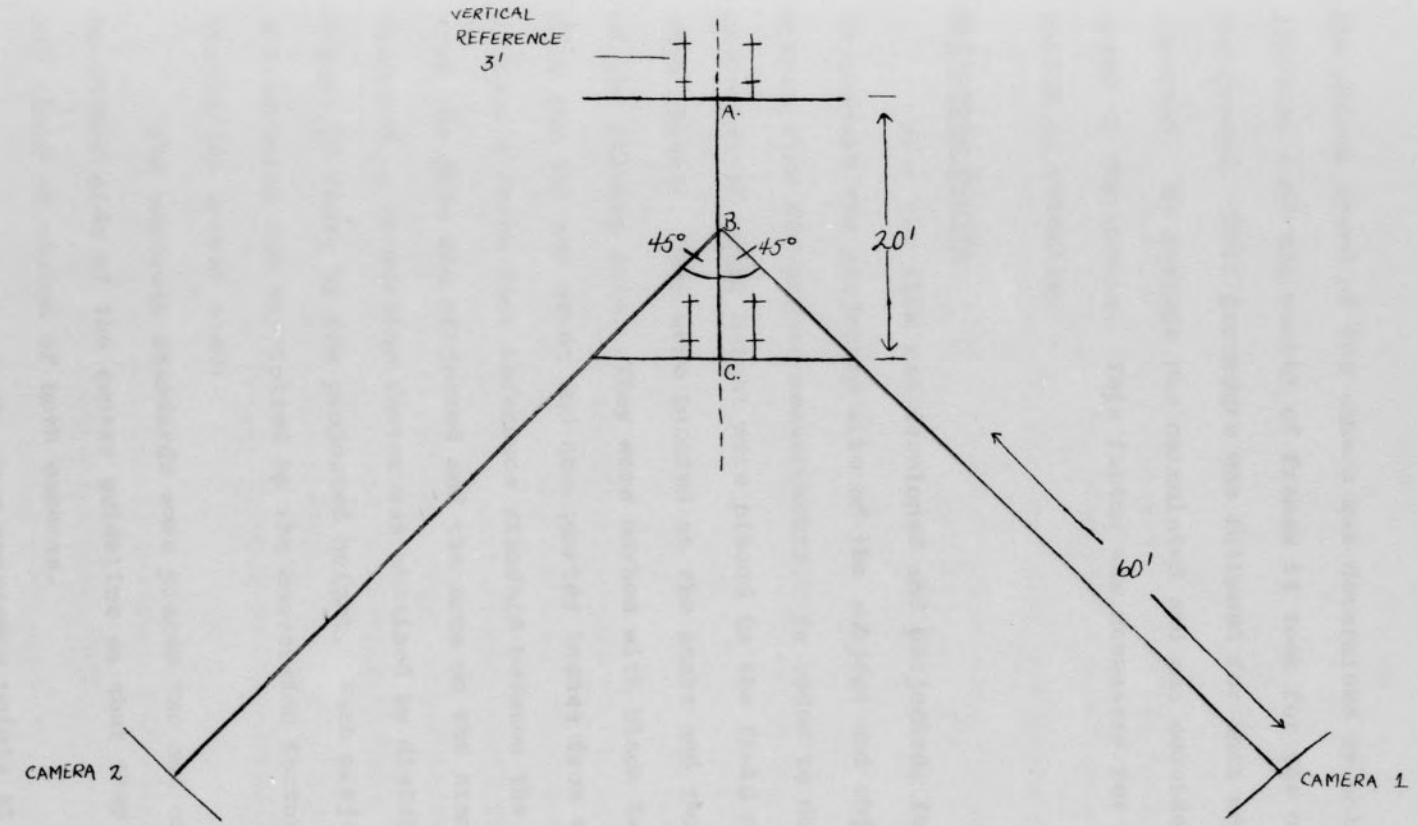

FIGURE 1

DIAGRAM OF THE FILMING SITUATION

The actual speed of the camera was determined by solving for t and dividing t by the number of frames it took for the object to hit the ground. This procedure was followed for each measurement frame recorded. An average was calculated and was considered the actual speed of the camera. This factor was necessary for proper calculation of velocity.

Reference Points

When the film was developed and projected, it was necessary to convert the projected size of the subject and objects to their actual size for proper measurements. In order to do this, vertical standards of equal height were placed in the field of vision of both cameras. Two were located at the start and two at the finish of the filming area. They were marked with black tape six inches from the top and seven and one-quarter inches from the bottom to produce a three foot reference standard between the two tape marks. When the film was projected and the area on the standards was measured, a conversion factor was obtained by dividing the known height (3 feet) by the projected height. Each projected image was measured and multiplied by the conversion factor in order to obtain the actual size.

The vertical standards were placed two and one-half feet on either side of the center guideline so that they remained in the field of vision of both cameras.

Thus, the standards were reference points at the start and finish of the filming area and the measurement frames served

as reference measures of size at point B, the midpoint of the filming area.

Subjects

The beginner was a rising junior at The University of North Carolina at Greensboro. She completed a fourteen week beginning course in lacrosse at The University in the spring of 1969.

The experienced player had taught physical education for one year. She played varsity lacrosse in college for four years, and was playing for the Boston Women's Lacrosse Association.

Both subjects wore black leotards, black tights, and black hockey shoes.

Marking the Subjects

Three-quarter inch wide yellow and three-quarter inch wide black tape were used to mark the subjects. Yellow tape was placed on the clothed areas and black on the skin. This procedure was followed in order that a contrast would appear in the developed film and the marked areas would be clearly visible. The tape was placed at the following areas:

1. across the knuckles, between the metacarpals and the phalanges;
2. around the wrist joints, connecting the styloid processes of the radius and ulna;
3. around the elbow joints, connecting the medial and lateral epicondyles of the humerus;

4. around the knee joints, connecting the medial and lateral condyles of the femur and tibia passing across the patella;
5. around the ankle joints, connecting the medial and lateral malleoli of the tibia and fibula, respectively;
6. an "X" placed on the backbone of the crosse.

These markings enabled the author to locate each joint and measure the angles more accurately. Each subject also wore two strips of two inch wide white tape to measure rotation. One was placed around the pelvic region and one around the thoracic region. A three-quarter inch wide strip of black tape was placed at the center of each white strip to account for the position of the trunk from frame to frame.

While the cameras remained focused on the filming area, the subjects began to run and cradle, one at a time, into the field of vision and toward the cameras. This was repeated five times by each subject in order to insure a sufficient amount of film from which to choose the best sequence. The line through the center of the filming area acted as a guide for their path. The subjects were directed to maintain their run between the vertical standards and relatively close to the line so that any additional perspective errors were eliminated. Therefore, although the distance from the camera was changing with every step forward, there was little change in distance caused by lateral movement.

Collection of Data

The film was read on a Recordak Film Reader. The cradles which were selected for analysis were chosen on the following basis.

1. The film was clear.
2. The markings on the subject and on the reference points were observable.
3. The performance was representative of the individual's average execution of the skill as it was viewed in the remaining sequences.

These criteria were used for both films. Comments were noted for each sequence in each film. Then the cradle was chosen and matched with the other film.

Frames in the chosen sequences were traced from the Recordak Film Reader. The markings on the joints were especially noted. The angles formed at the elbow, knee, forearm to cradle, cradle to ground, and wrist, where possible, were measured on the traced copy with a protractor. In order to be consistent in the measurement of angles, the author used the measurement of less than 180 degrees when there was flexion of the body parts and more than 180 degrees when there was extension of the body parts. Rotation at the pelvic and thoracic regions was measured by superimposing the tracing of the preceding frame and tracing the marking from the tape around that region. A ruler measuring in thirty-second's of an inch was used to record the change.

The author attempted to match the first frame of the chosen sequence from each film and for each subject by using the measurement at the knee joint and position of the crosse in relation to the body as the criterion.

CHAPTER IV

ANALYSIS OF DATA

Figures 8, 9, 10 and 11 in the Appendix and Tables I, II, III and IV present the angles as they were measured from the traced image. Where it was impossible to see the tape markings on the wrist or across the knuckles, no measurement was taken for that frame. In many cases, the marking on the tape positioned around the pelvic and thoracic regions was not clear. Therefore, the measurement of rotation was limited.

The actual speed of the camera was calculated by using the formula $S = \frac{1}{2}gt^2$ and the ratio $\frac{\text{number of frames the shot took to fall}}{t} = \frac{X}{1 \text{ sec.}}$. By solving for X in the ratio, the actual speed of the camera was obtained. The actual speed of camera one was 54 frames per second and 47 frames per second for camera two.

The actual vertical reference points at the beginning, middle, and end of the filming area measured three feet. In the projected film, however, they measured one inch, one inch, and 1.125 inches respectively. Therefore, the conversion factor of thirty-six inches was used in all frames with the exception of the following: Table III, frames four through eleven and Table IV, frames four through thirteen, where thirty-two inches was used. It was in these frames that the subject was closer to the

TABLE I

ANGULAR AND LINEAR MEASUREMENTS FROM THE CAMERA ONE EXPERIENCED PLAYER SEQUENCE

Frame	Left Elbow	Left Knee	Right Wrist	Left Wrist	Crosse Ground	Crosse Left Forearm	Crosse Ground (Inches)
1	164	162	145		85.5	37.5	31.5
2	144	157.5	160.5		90	59	33.75
3	124	155		204	93	76	30.375
4	144.5	165		165	84	62.5	32.625
5	149	162.5	208	165	81.5	57	31.5
6	156.5	167		168	90	66.5	31.5
7	157	161.5	182	162	82.5	75	31.5
8	153	161	188	138	71.5	65.5	32.625
9	152.5	132.5	187.5		67.5	80	30.375
10	155	129			72	84	33.75
11	152	79		155	67.5	83.5	36.0
12	150.5	79		150	79	88.5	37.125
13	146	170		144.5	81	85.5	36.0
14	163	106.5		144	82.5	72.5	34.875
15	152.5	96		151.5	87	72	34.875
16	136.5	98		156	83	71	32.625
17	153.5	106.5		169	89	68.5	30.375
18	162.5	74	195	179	89	42	34.875
19	148.5	112			90	54	31.5
20	148	135	179	184	88	43	29.25
21	140	145	179	188	90	41	29.25
22	150	143			87	35	28.25
23	145	159	176.5	210	81.5	35	28.25
24	146.5	163	170	250.5	89	42	28.25
25	150	165	164.5	243	91.5	37.5	30.375
26	162.5	174			89	25.5	30.375
27	153.5	161			91	45	33.75
28	148	173	160	210		51	32.625

TABLE II

ANGULAR AND LINEAR MEASUREMENTS FROM THE CAMERA TWO EXPERIENCED PLAYER SEQUENCE

Frame	Right Elbow	Right Knee	Right Wrist	Left Wrist	Crosse Ground	Crosse Right Forearm	Crosse Ground (Inches)
1	120	69.5		194	76.5	56.5	34.875
2	113	86		215	76	54.5	34.875
3	92	88			77	48.5	34.875
4	76	110			80	39	29.25
5	71	118.5			77.5	33.5	31.5
6	63	123.5		162	76.5	27	32.625
7	60	131		179	80.5	23.5	36.0
8	41	145	227	157.5	75	13.5	33.75
9	58	156	235	162.5	77	14	33.75
10	35	163.5		171	73.5	15	32.625
11	80	168			67.5	27	30.375
12	78	167			76.5	23.5	29.25
13	90	167		171	81.5	12.5	36.625
14	88	155.5			82	26	32.625
15	92.5	153.5			87.5	25.5	32.625
16	105.5	152.5			84.5	36.5	31.5
17	125	158			82.5	38	34.875
18	112	148			85	37	33.75
19	129	163			86.5	47	37.125
20	132	162	189		82	50	36.0
21	126	168			92	38	30.375
22	132.5	173			90	48	31.5
23	139	172			88.5	49.5	31.5
24	148	180			89	56.5	36.0
25	146	160.5			85	60	30.375
26	149.5	159	187		86	59	30.375
27	145	139			83.5	53.5	31.5
28	143.5	119.5			84	59.5	31.5
29	141	84.5			72.5	61.5	31.5
30	129	69.5			75.5	56	32.625
31	141	66			75	60	32.625
32	132.5	70			76	57	34.875

TABLE III

ANGULAR AND LINEAR MEASUREMENTS FROM THE CAMERA ONE BEGINNER SEQUENCE

Frame	Left Elbow	Left Knee	Right Wrist	Left Wrist	Crosse Ground	Crosse Left Forearm	Crosse Ground (Inches)
1	155	155.5		200.5	74.5	51.5	34.875
2	145	151			71.5	51	33.75
3	150	132		180	74.5	60.5	34.875
4	159	142			75	58.5	29.0
5	147	133			78	65	28.0
6	152	139			77	69.5	28.0
7	161	147			79	60	28.0
8	160	148.5			67	71	32.0
9	151	165			75	64.5	29.0
10	162	129			79	46	31.0
11	165.5	130		141	79.5	50	31.0
12	151.5	91		193.5	80.5	61	33.75
13	149.5	111		195.5	78	57.5	31.5
14	144	97		196.5	73	63.5	31.5
15	138.5	98		189.5	72.5	61	31.5
16	146	105.5		187.5	73	55	32.625
17	135.5	117.5		180	78.5	55	33.75
18	149.5	124			78	47	33.75
19	153	133.5			75	47	32.625
20	156	147		220	73	47.5	32.625
21	147	146.5			73.5	46.5	31.75
22	153.5	166		214	75.5	44	32.625
23	158.5	163		225	74	43	32.625
24	145	170		181	73	53.5	32.625
25	145.5	164			79.5	47	31.5
26	156.5	162.5			70	55	31.5

TABLE IV

ANGULAR AND LINEAR MEASUREMENTS FROM THE CAMERA TWO BEGINNER SEQUENCE

Frame	Right Elbow	Right Knee	Right Wrist	Left Wrist	Crosse Ground	Crosse Left Forearm	Crosse Ground (Inches)
1	94	95	181	166	80	29	37.125
2	94	90	183	166	81	33.5	32.625
3	92.5	91.5	189.5		87	28	31.5
4	83	77	190		78	27	28.0
5	59	82.5	180		79	23.5	28.0
6	70	89	180		81.5	27	28.0
7	70	96	190		88.5	42	30.0
8	59.5	103	187.5	150	83.5	30	32.0
9	34.5	120		168.5	86	21.5	31.0
10	51	124		160.5	83.5	19	32.0
11	55.5	143.5			83	22.5	28.0
12	46.5	156	225	160	89	12	28.0
13	46.5	161.5			88	18.5	30.0
14	46	152			89	17.5	34.875
15	49	149			89	13.5	31.5
16	55	153			87	25	36.0
17	73.5	144	164		85	26	33.75
18	94.5	147	180		84.5	38	36.0
19	87	153.5			86	34	36.0
20	100	156			90	45	31.5
21	99	167.5	178	215	85	37.5	33.75
22	110	166.5	177.5	222	86.5	40	33.75
23	116.5	172.5			73.5	31	36.0
24	109	168.5	180		83	36.5	38.25
25	114.5	167	178	189	75	30	34.875
26	123.5	159.5	177	217	72.5	32	37.125
27	123.5	130.5			77	35.5	36.0
28	119	130			76	33	34.875
29	123	113.5			77	38	36.0
30	113.5	96.5			75	35	37.125
31	112.5	90.5			76.5	32	34.875

reference points at the end of the filming area than she was to the middle reference point.

The velocity at which each subject ran from the start to the finish of the filming area was calculated by counting the number of frames that elapsed between the start and the finish of the complete run. The following procedure was used to determine the velocity:

1. $$\frac{\text{Actual speed of the camera per second}}{1} = \frac{\text{counted number of frames}}{\text{time}}$$

(solve for time)

2. $$\text{Velocity} = \frac{\text{Distance}}{\text{time}}$$ (solve for velocity)

For each complete run out of which a sequence was selected, the velocity of the subject was calculated as filmed by camera one and as filmed by camera two. An average of these two velocities was determined for each subject and was considered the average velocity.

The average velocity of the beginner from the start to the finish of the filming area was calculated to be 14.67 feet per second. The average velocity of the experienced player was 15.80 feet per second.

Position of the Crosse

Experts agree that the crosse is in a vertical position in front of the body once it is gripped. (See Figure 2 and 3)

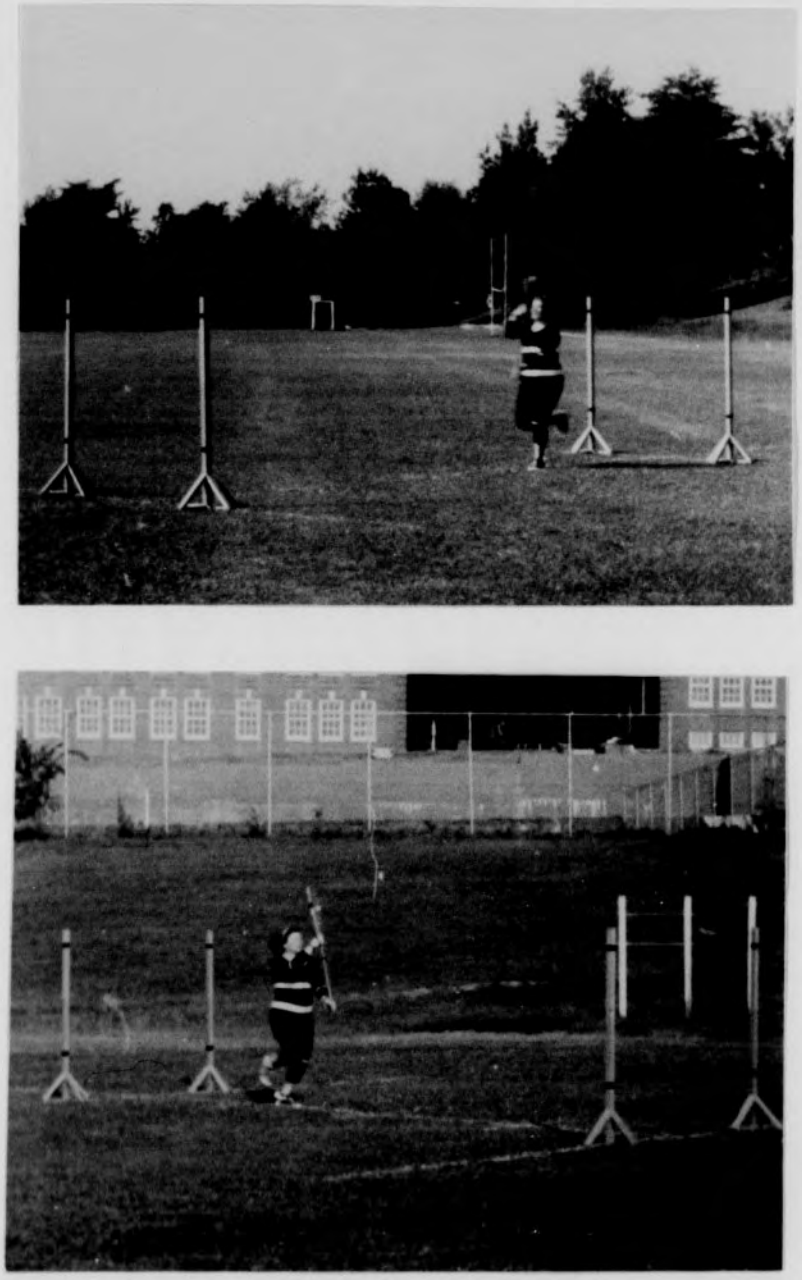

FIGURE 2

CROSSE POSITIONED IN FRONT OF EXPERIENCED PLAYER AS TAKEN WITH CAMERA ONE (TOP) AND CAMERA TWO (BOTTOM)

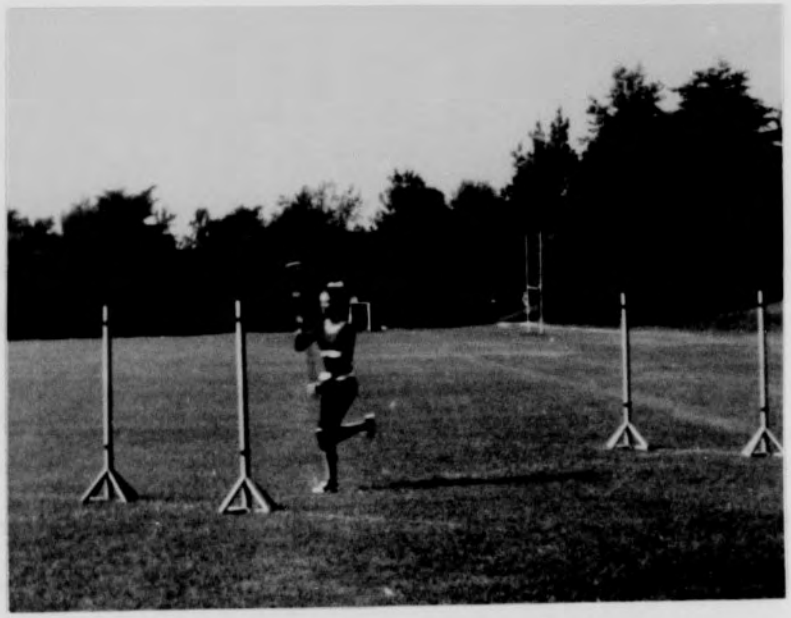

FIGURE 3

CROSSE POSITIONED IN FRONT OF BEGINNER
AS TAKEN FROM CAMERA ONE (TOP)
AND CAMERA TWO (BOTTOM)

This is vague and often interpreted to mean that the crosse should be held in a position perpendicular to the ground. However, as shown in the tables, the crosse seldom measured to form a 90 degree angle with the ground. The farther it traveled from the front of the body, the greater was the difference between the measured angle and 90 degrees.

Swing to the Right

Experts state that the left wrist flexes to complete the swing to the right. (See Figures 4 and 5) The analysis was in agreement with the experts. Frames three through eight in Table I, page 21, show the angle at the wrist flexing toward the body. It changes from 204 degrees in frame three to 138 degrees in frame eight, a range of 66 degrees. Frames six, seven and eight in Table II, page 22, show that the wrist flexed from 162 degrees in frame six to 157 degrees in frame eight, a range of 5 degrees. The beginner's range in flexion was not as large as the experienced player's. Frames three and eleven in Table III, page 23, show the angle decreased from 180 degrees to 141 degrees, a range of 39 degrees. Frames two, eight, nine, ten and twelve in Table IV, page 24, show the angle of flexion to vary from 166 degrees in frame two to 160 degrees in frame twelve, a range of 6 degrees.

Authorities have also stated that the right wrist "slightly" extends at the end of the swing. The analysis was in agreement with the authorities and presents a more objective estimate of "slightly" extends. Frames one, two, five, seven and eight in

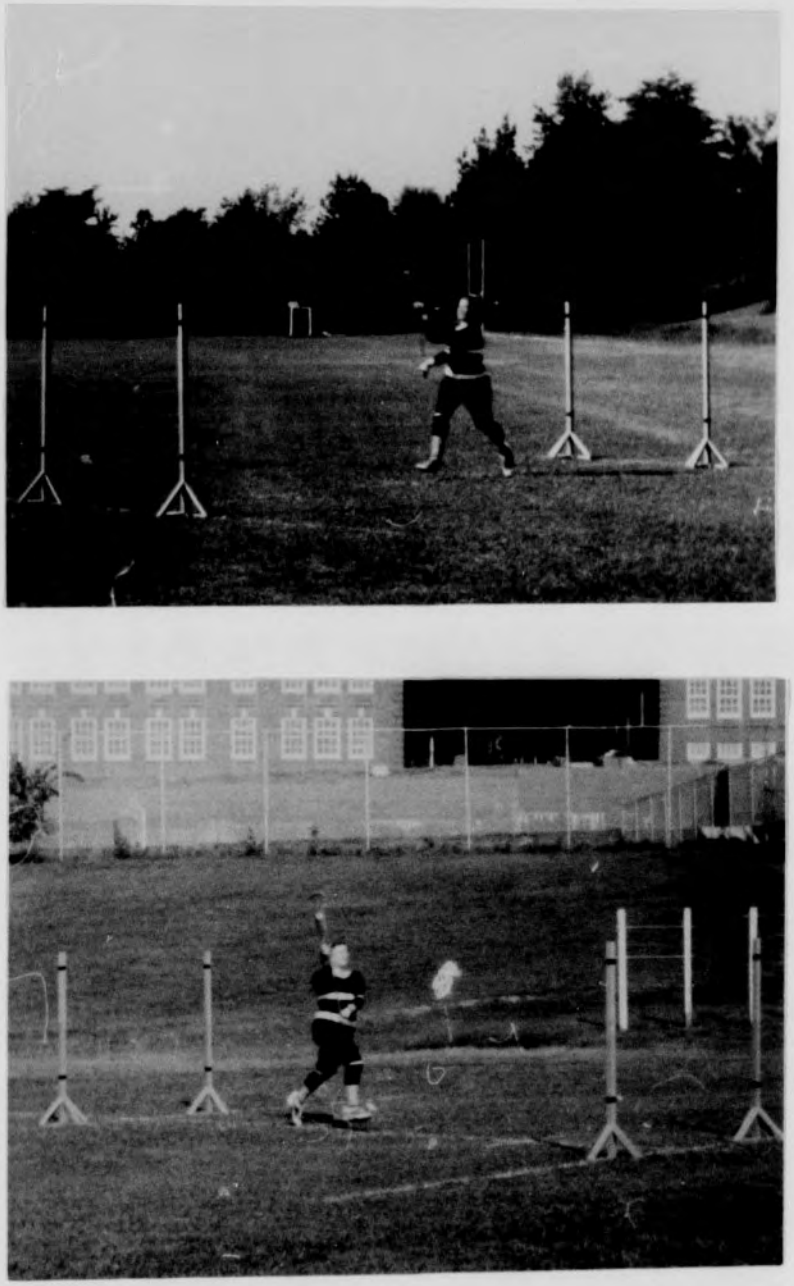

FIGURE 4

EXPERIENCED PLAYER'S SWING TO THE RIGHT
FROM CAMERA ONE (TOP) AND
CAMERA TWO (BOTTOM)

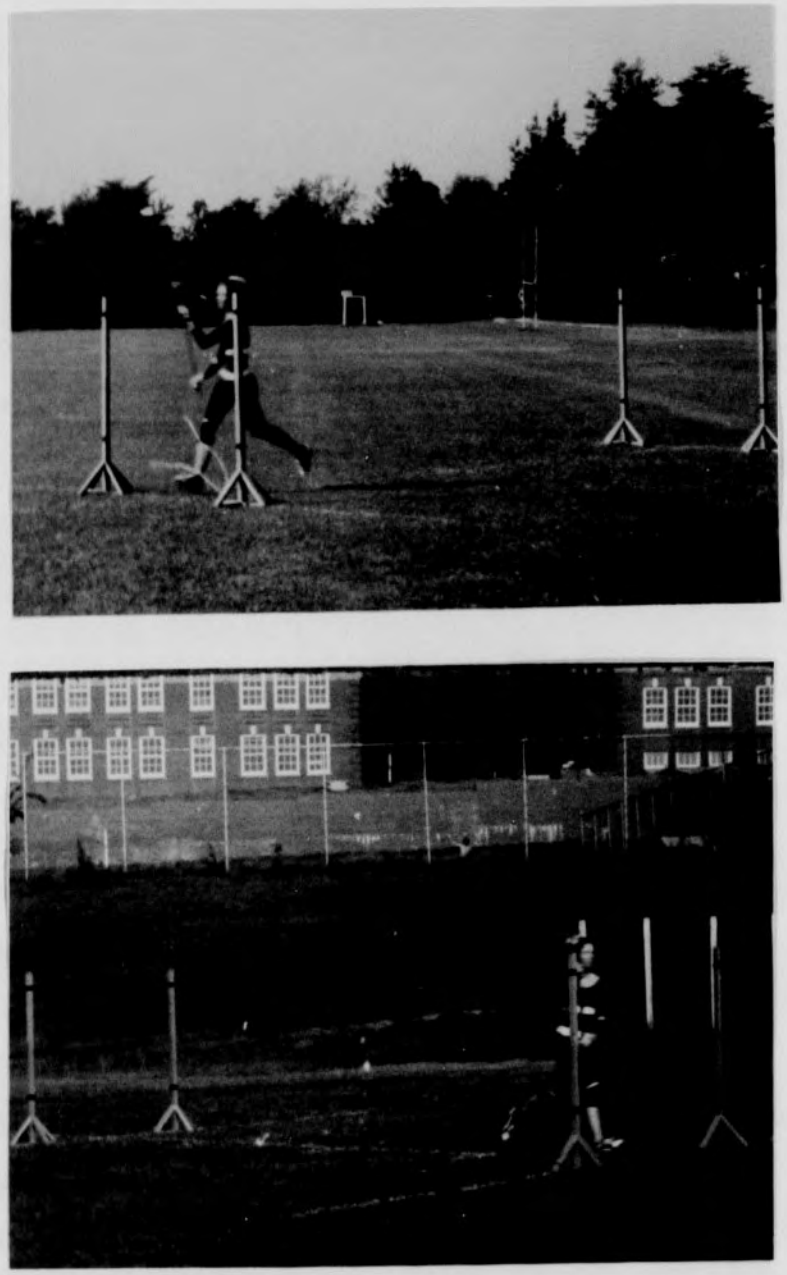

FIGURE 5

BEGINNER'S SWING TO THE RIGHT FROM CAMERA
ONE (TOP) AND CAMERA TWO (BOTTOM)

Table I, page 21, show a range of 43 degrees for the experienced player as the angle varied from 145 to 188 degrees. Frames two through eight and frame twelve in Table IV, page 24, show a range of 32 degrees. The angles varied from 183 to 225 degrees.

Finally, it is written by experts that the forearm of the top hand (right) remains as close to the stick as possible. The measurements show that in frames three through eight in Table II, page 22, the angles between the crosse and the right forearm decreased 35 degrees from 48.5 degrees in frame three to 13.5 degrees in frame eight in accordance with the statements of experts. Frames two through twelve in Table IV, page 24, show a decrease in angle from 33.5 degrees to 12 degrees, a range of 21.5 degrees for the beginner.

Swing to the Left

Experts agree that the right wrist returns from extension and flexes as much as possible at the end of the swing to the left. (See Figures 6 and 7) Frame eighteen and frames twenty through twenty-five in Table I, page 21, show an increase in the angle of flexion from 195 degrees to 164.5 degrees, a range of 30.5 degrees.

The beginner in frames seventeen, eighteen, nineteen and frames twenty-two through twenty-three in Table III, page 23, shows an increase in the angle of flexion from 179 degrees to 169.5 degrees, a range of 10.5 degrees.

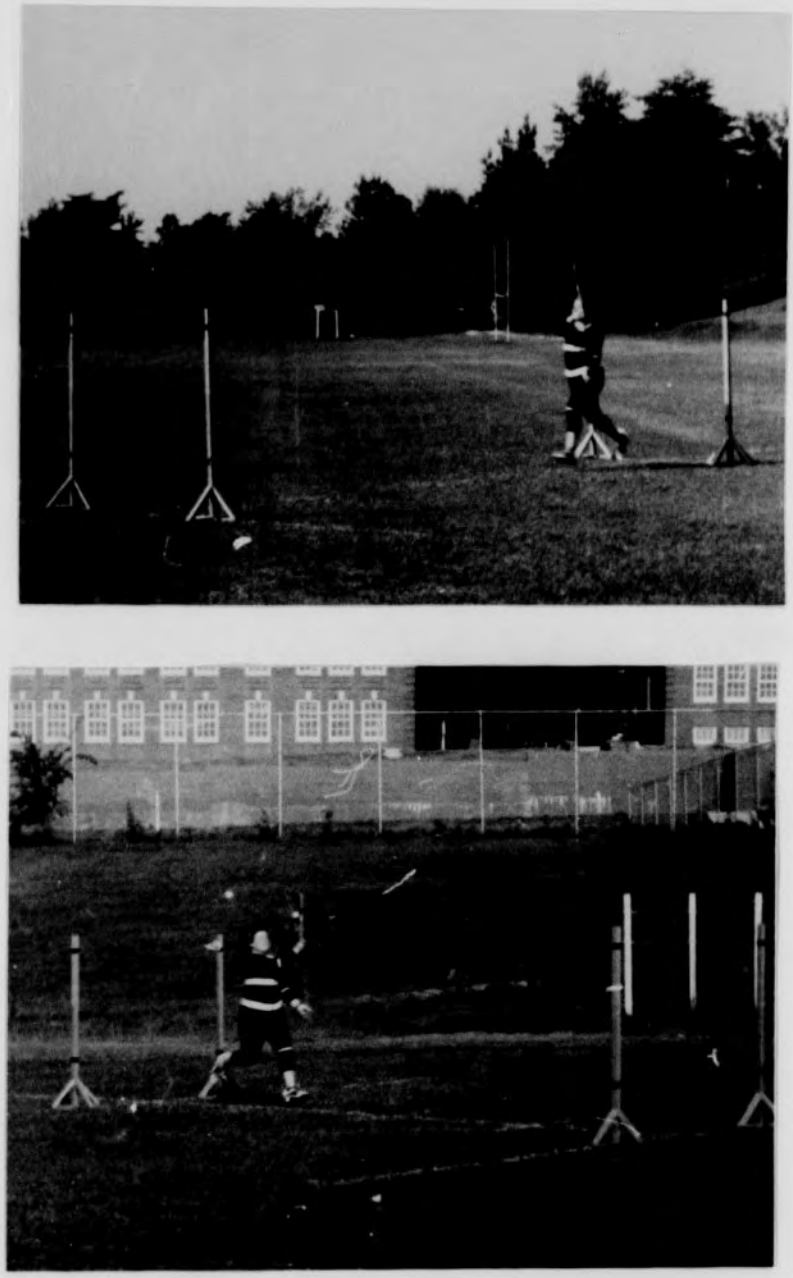

FIGURE 6

EXPERIENCED PLAYER'S SWING TO THE LEFT
FROM CAMERA ONE (TOP) AND
CAMERA TWO (BOTTOM)

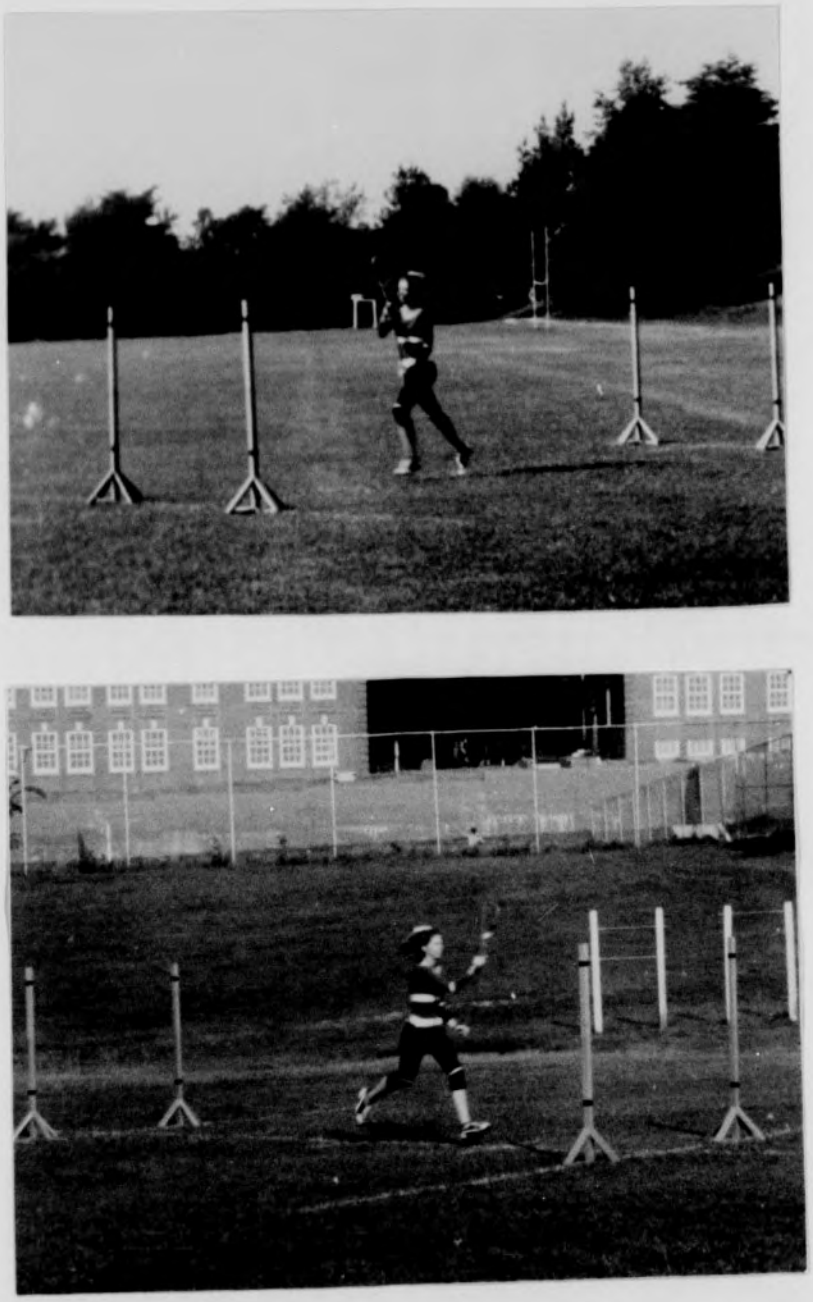

FIGURE 7

BEGINNER'S SWING TO THE LEFT FROM CAMERA
ONE (TOP) AND CAMERA TWO (BOTTOM)

The left wrist is said to extend when the crosse is swung to the left. In frames twenty through twenty-five in Table I, page 21, the left wrist measured from a position in front of the body at 184 degrees to the extreme left of the body at 243.5 degrees, a range of 59.5 degrees. Frames seventeen, twenty, twenty-two and twenty-three in Table III, page 23, show the angle of the left wrist extends from 180 degrees to 225 degrees, a range of 45 degrees for the beginner.

Experts also agree that the left forearm remains parallel to the ground and at waist level. The subjects in this study did not perform in accordance with the statement. The distance between the waist and the ground of the experienced player was converted to the actual size of 38.5 inches. Her left forearm traveled from an extreme of 37.125 inches from the ground to a low of 28.25 inches from the ground. The beginner's waist measured 40.5 inches from the ground using the 36-inch conversion factor and 38 inches using the 32-inch conversion factor. Her left forearm reached a high point of 38.25 inches and a low point of 31.5 inches using the 36-inch factor. It reached a high point of 32 inches and a low point of 28 inches, when the 32-inch factor was used. The author used both conversion factors due to the fact that the beginner was closer to the one and one-eighth inch projected reference point than she was to the one inch projected reference point. Although the experienced player came closer to the suggested height while cradling, both subjects maintained their left forearm at a position below the waist throughout most of the skill performance.

Rotation

It was difficult to see the tape markings around the pelvic and thoracic regions. The black strip of tape placed on the center of the two inch white strip was too narrow. A one and one-half to two inch wide strip as opposed to a three-quarter inch wide tape is recommended. However, some measurements were obtained. Table V shows the degree of thoracic and pelvic rotation the subjects displayed in their skill performance from one frame to another. It was in this area of rotation that the experienced player showed the greatest distinction with relationship to skill performance. The experienced player employed her entire body in swinging the crosse from side to side while the beginner maintained a fairly stationary trunk position using just her arms to move the crosse.

Interpretation of Data

The experts state that the left forearm should be parallel to the ground and at waist level. This dictates that the position of the crosse be at or above the waist. Both the experienced and beginning player allowed their crosses to fall as much as 10.25 inches and 9.000 inches respectively below their waist. Since the experienced player has participated on highly competitive teams and finds success with the crosse below her waist, the above statement is questioned and further investigation is suggested.

The calculations of body angles revealed that both subjects employed considerable range of motion at the wrist, flexing and extending to move the crosse from one side to another. The experienced player showed a greater range of motion at the wrist than

TABLE V

ROTATION OF THE THORACIC AND PELVIC REGIONS IN THE LACROSSE CRADLE

Sequence	Frames	Region	Rotation Direction	Amount in Inches
2 *	22-23	thoracic	left	1.125
		pelvic	left	2.25
2 *	23-25	thoracic	left	2.25
		pelvic	left	2.25
2 *	25-26	thoracic	left	3.275
2 *	27-29	pelvic	left	2.25
2 *	29-30	pelvic	left	2.25
2 *	30-5	thoracic	right	2.25
2 *	5-6	thoracic	right	3.275
2 *	6-7	thoracic	right	2.25
		pelvic	right	2.25
2 *	7-8	thoracic	left	2.25
3**	16-26	thoracic	left	2.25
3**	26-2	thoracic	right	1.125
4***	1-6	pelvic	right	2
4***	6-8	pelvic	right	2
4***	17-21	thoracic	right	1

* Experienced Player, See Appendix, Figure 9.
** Beginning Player, See Appendix, Figure 10.
*** Beginning Player, See Appendix, Figure 11.

did the beginner. Little trunk rotation was noted, especially from the beginner.

The "vertical" position of the crosse was analyzed to be less than 90 degrees in most frames. This factor did not prevent the execution of the skill.

The subjects performed the skill in accordance with the description of experts with the exception of two elements:

1. the angle of the crosse to the ground,
2. the position of the crosse in relation to the waist of the subject.

Both subjects did not maintain the crosse at waist level but allowed it to drop below their waists.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to investigate the lacrosse cradle through cinematographic analysis. The investigation included an analysis of joint angles throughout the execution of the skill and a close examination of the position of the crosse with relation to the body and the ground.

The skill was executed by two individuals of differing experience in the game of lacrosse. One was a beginner who had completed a semester of a beginning lacrosse activity class but had not competed at the varsity level. The other subject was an experienced player who had participated competitively in the game of lacrosse. The skill performance of both subjects was analyzed and dominant distinctions in execution were noted. Analysis was, in some instances, facilitated by comparing the subjects' execution of the skill, but comparison was not a primary purpose.

Two lines were drawn a distance of twenty feet apart on the athletic field at The University of North Carolina at Greensboro and served as the actual filming area. Another line was drawn perpendicular to the first two and through the center of them. This last line served as a guide which the subjects used as they performed the skill.

Vertical reference poles were placed at the start and finish of the filming area and were used to calculate conversion factors in order to convert the projected images to actual size. A measurement frame for size, using a yardstick, was the reference point used for conversions when the movement occurred in the center of the filming area.

Two 16mm Bolex movie cameras were used, each with a 25mm lens and a tripod. The cameras were set to run at 64 frames per second. They were placed at a 45 degree angle to the midpoint of the filming area and 60 feet from that point. The cameras were set on tripods and measured four and one-eighth inches from the ground to the bottom of the lens. The film used was negative Eastman, type 7231, PXN 449.

The cameras remained fixed and focused on the filming area. The subjects then began to run and cradle, one at a time, into the field of vision and toward the cameras. The subjects were directed to maintain their run between the vertical standards and relatively close to the line so that any additional perspective errors were eliminated. The skill was performed five times by each subject.

The subjects wore black leotards, black tights, and black hockey shoes. White and yellow tape was used to mark the joints which were covered by clothing. Black tape was used on the skin. The wrists, elbows, knuckles (joint between the metacarpals and phalanges), knees, ankles, toes and heels were marked along with placement of tape around the thoracic and pelvic regions. An "X"

was placed on the backbone of the crosse to aid in identifying its position.

The actual speed of one camera was calculated to be fifty-four frames per second and forty-seven frames per second for the second camera. These calculations were made in accordance with the method described by Cureton in the May 1939 Research Quarterly.

The film was read on a Recordak Film Reader and the best matching sequences were chosen for analysis. The figures were traced from the film. The angles formed at the elbow, knee, cradle to forearm, cradle to ground, and wrist, where possible, were measured on the traced copy with a protractor. Rotation at the pelvic and thoracic regions was measured by superimposing the tracing of the preceding frame and tracing the marking from the black tape at that region. A ruler measuring in eighth's of an inch was used to record the change. The distance of the crosse to the ground was also measured with the above mentioned ruler.

Results

1. The crosse measured a 90 degree angle with the ground three out of sixty frames for the experienced player and one out of fifty-seven frames for the beginner.
2. The angle formed by the crosse and the right forearm of the experienced player showed a decrease of 35 degrees from the start of the swing to the right to the final position at the right of the body. This angle for the beginner was measured to decrease 21.5 degrees. Both

were measured from the film taken with camera two.

3. The angle formed by the crosse and the left forearm of the experienced player showed a decrease of 48 degrees from the start of the swing to the left to the final position at the left of the body. This angle for the beginner measured to decrease 20.5 degrees. Both were measured from the film taken with camera one.
4. The angle formed at the left wrist joint of the experienced player when the crosse was swung to the right, revealed a decrease of 66 degrees from a position of 204 degrees at the start to a position of 138 degrees at the finish. This angle for the beginner showed a decrease of 39 degrees from a position of 180 degrees at the start to a position of 141 degrees at the completion of the swing. Both measurements were calculated from the film taken with camera one.
5. The right wrist of the experienced player showed an extension of 43 degrees when the crosse was swung to the right. The joint was extended from a position of 145 degrees to a position of 188 degrees. The beginner's wrist measured a change of 32 degrees from a position of 183 degrees to 225 degrees. The angle of the experienced player was measured from the film taken by camera one and that of the beginner with camera two.

6. When the crosse was swung to the left, the right wrist of the experienced player flexed to 164.6 degrees from an extended position of 195 degrees at the start of the swing, a decrease of 59.5 degrees. The beginner showed a decrease of 10.5 degrees from 179 degrees to 169.5 degrees at the end of the swing. Both angles were measured from the film taken with camera one.
7. The left wrist of the experienced player extended, when the crosse was swung to the right, from a position of 184 degrees at the start to 243.5 degrees, an increase of 59.5 degrees. The beginner showed an increase of 45 degrees from 180 degrees to 225 degrees at the end of the swing. Both angle measurements were calculated from the film taken with camera one.
8. Both experienced and beginning players allowed their crosses to fall as low as 10.25 inches and 9.000 inches respectively below their waist. The beginner allowed it to drop eight inches using 32 inches as the conversion factor.
9. The greatest measured thoracic and pelvic rotation to both the left and right of the experienced player was 3.275 inches and 2.25 inches respectively. The greatest measured thoracic rotation to the right of the beginning player was 1.125 inches and 2.25 inches to the left. The greatest measured pelvic rotation to the right of the

beginning player was two inches. No measurement was obtained for the beginner's rotation to the left.

Conclusions

Generally, the cinematographic analysis of the skill performance of the two subjects proved to be in accordance with the opinions of experts. The major distinctions between opinion and performance were found to be in the position of the forearm in relation to the ground and the waist of the subjects and the position of the crosse to the ground.

Although the beginner and the experienced player flexed and extended their wrists in accordance with the expert descriptions, the experienced player demonstrated a greater range of motion in the joints. Finally, the measurements obtained from the film with regard to body rotation revealed that the beginner did not move her body from the forward position to any great degree. More rotation was measured from the film taken of the experienced player.

Recommendations

It is recommended that cinematographic analysis of the overarm pass, underarm pass, pick-up and dodge be conducted. Further studies should include a greater number of subjects in order to make comparisons within and between skill levels. A study could also be conducted testing the speculation that the

less mentioned to the beginner concerning the vertical position of the crosse and the maintenance of its position at waist level, the less inhibited the beginner would be to cradle in a greater arc from one side of the body to the other.

It is also recommended that wider tape be used as the markings placed on the tape around the thoracic and pelvic regions for increased visibility. In order to enhance the clarity of the markings on the wrist and knuckles, the wearing of a black glove and using white tape to mark the areas is also recommended.

BIBLIOGRAPHY

BIBLIOGRAPHY

A. BOOKS

1. Boyd, Margaret. Lacrosse Playing and Coaching. London: Nickolas Kaye, 1959.

2. Bunn, John W. Scientific Principles of Coaching. New Jersey: Prentice-Hall, Inc., 1955.

3. Burbeck, Louise G. and Helena A. Wheeler. Lacrosse for Girls. Lithographed in the United States of America, 1958.

4. Morrill, W. Kelso. Lacrosse. New York: The Ronald Press Company, 1966.

5. Stenning, Mary. "A Few Elementary Thoughts on Teaching Beginners," in Sports Articles Reprint Series, Selected Hockey and Lacrosse Articles, ed. Caryl M. Newhof. The Publications Committee National Section for Girls and Women's Sports, American Association for Health, Physical Education and Recreation, 1955.

6. Vannier, Mary Helen and Hally Beth Poindexter. Individual and Team Sports for Girls and Women. Philadelphia: W. B. Saunders Company, 1968.

B. PERIODICALS

7. Cureton, Thomas K. "Elementary Principles and Techniques of Cinematographic Analysis as Aids in Athletic Research," Research Quarterly, X (May, 1939), pp. 3-24.

C. UNPUBLISHED MATERIALS

8. Barth, Dorothy Ann. "A Cinematographic Analysis of The Badminton Backhand Stroke." Unpublished Masters thesis, University of Illinois, Urbana, 1961.

9. Bordan, Paul. "A Cinematographic Analysis of the Three Basic Kicks Used in Soccer." Unpublished Master's thesis, Pennsylvania State University, 1955.

10. Quandt, Harlan Harvey. "A Cinematographic Analysis of the Palm Ball Pitch Compared to the Fast Ball Pitch in Baseball." Unpublished Master's thesis, University of Wisconsin, Madison, 1964.

11. Sarver, Robert Edward. "A Cinematographic Analysis of the Double Leg Circle on the Side Horse." Unpublished Master's thesis, Washington State University, 1962.

12. Wrigglesworth, Frank L. "A Cinematographic Analysis of the Short Chip Shot in Golf." Unpublished Master's thesis, University of Wisconsin, Madison, 1964.

APPENDIX

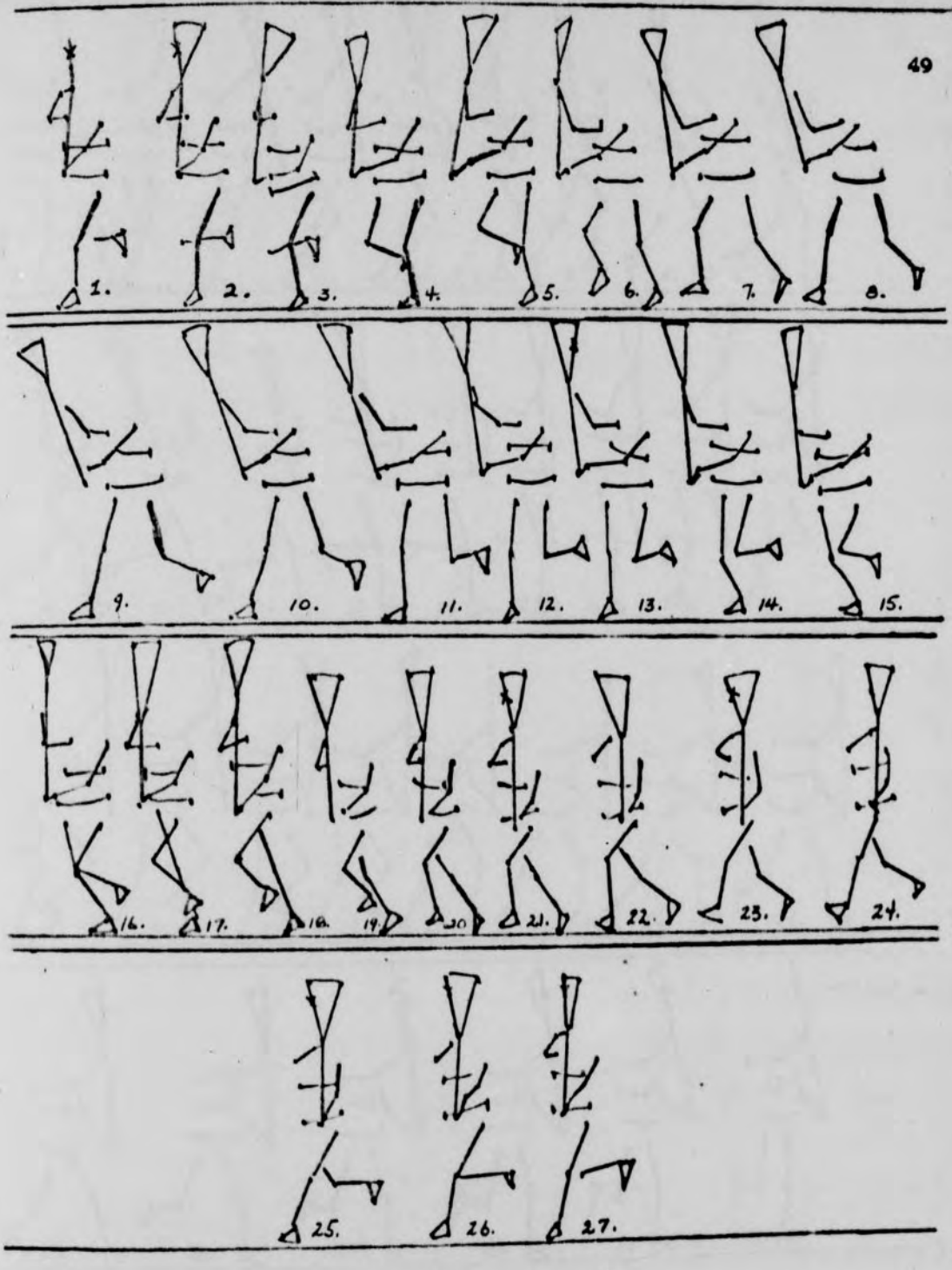

FIGURE 8

A SEQUENCE OF FRAMES OF THE EXPERIENCED PLAYER PERFORMING THE CRADLE AS TAKEN WITH CAMERA ONE

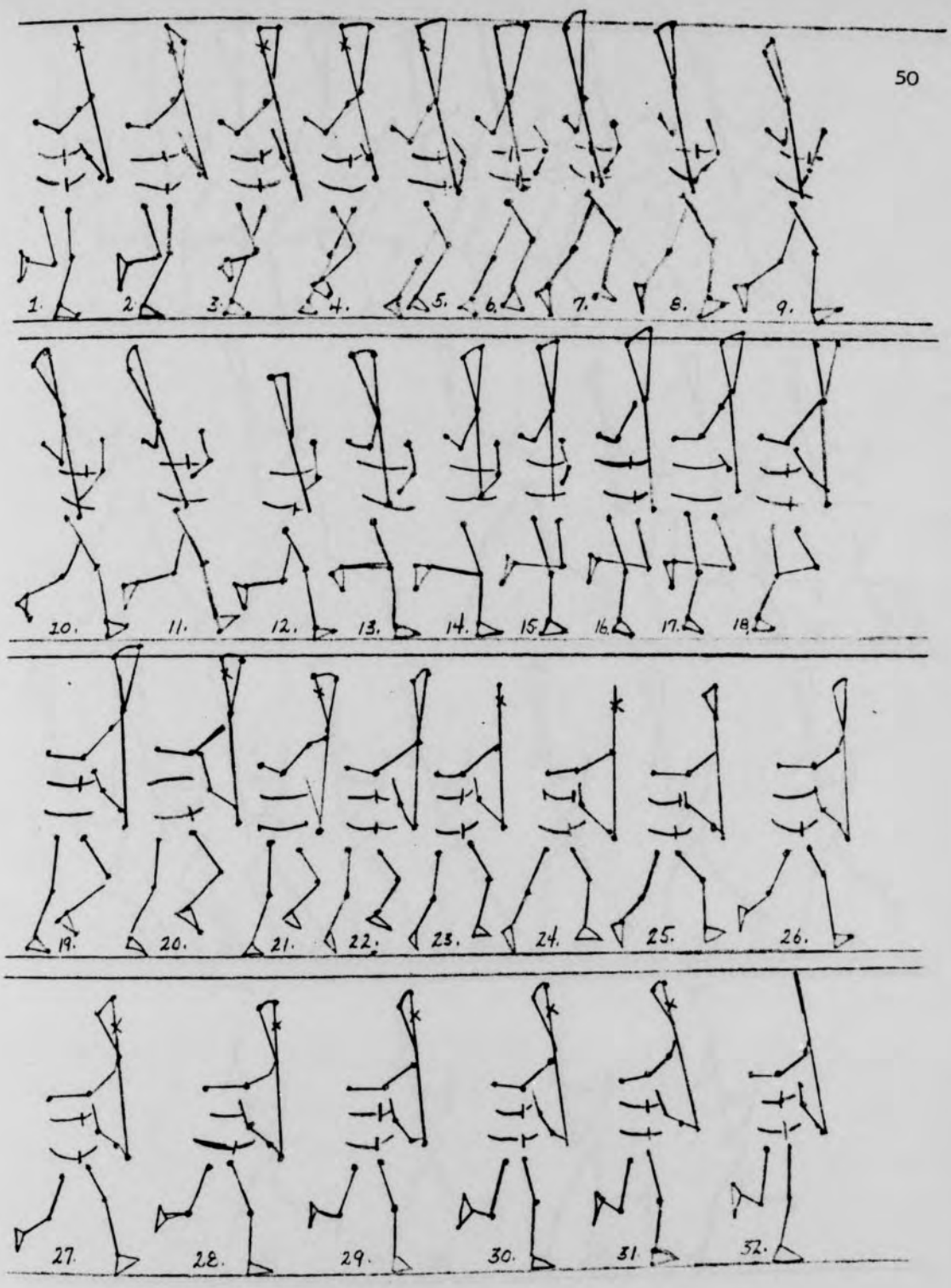

FIGURE 9

A SEQUENCE OF FRAMES OF THE EXPERIENCED PLAYER PERFORMING THE CRADLE AS TAKEN WITH CAMERA TWO

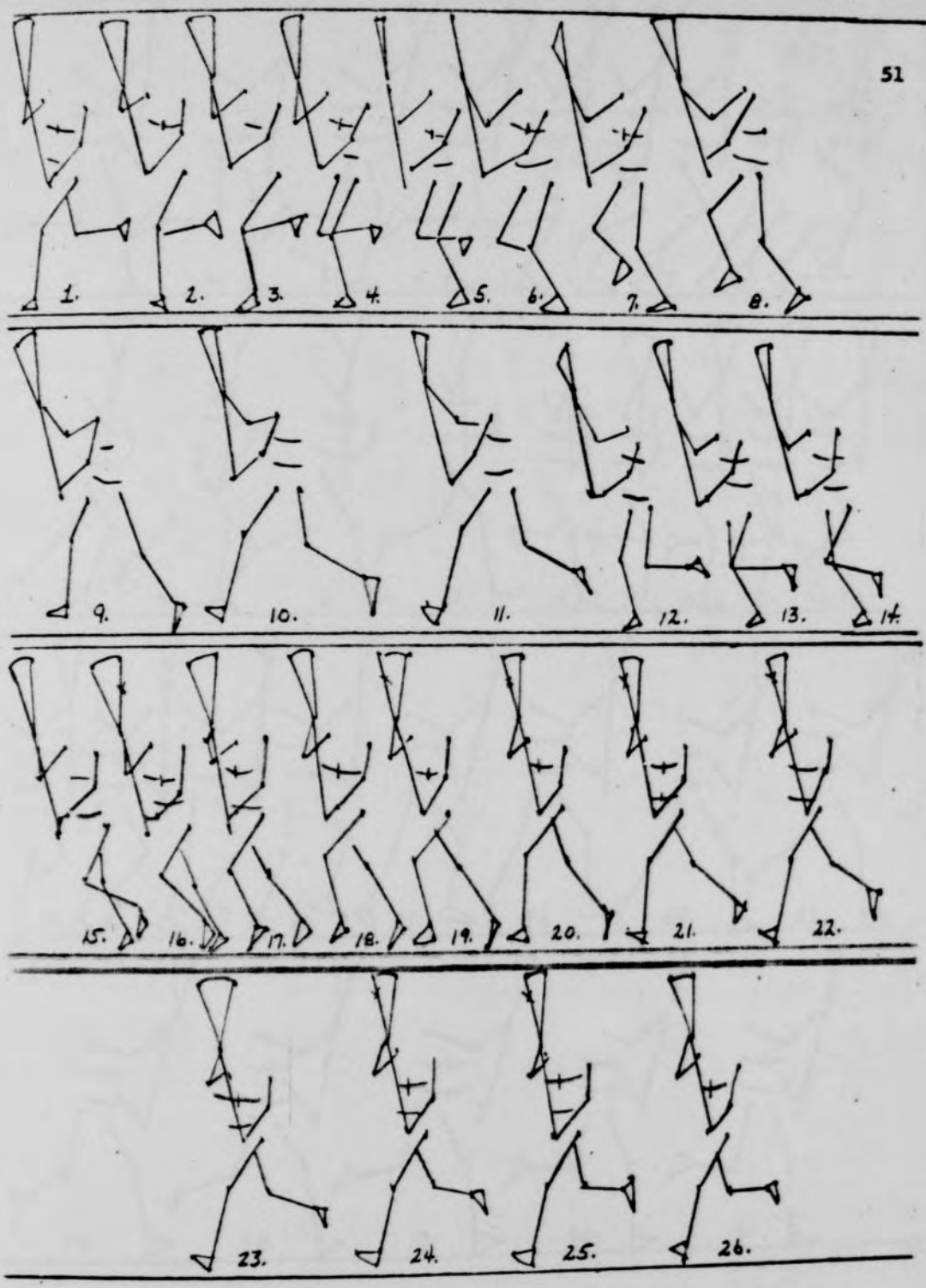

FIGURE 10

A SEQUENCE OF FRAMES OF THE BEGINNER
PERFORMING THE CRADLE AS TAKEN
WITH CAMERA ONE

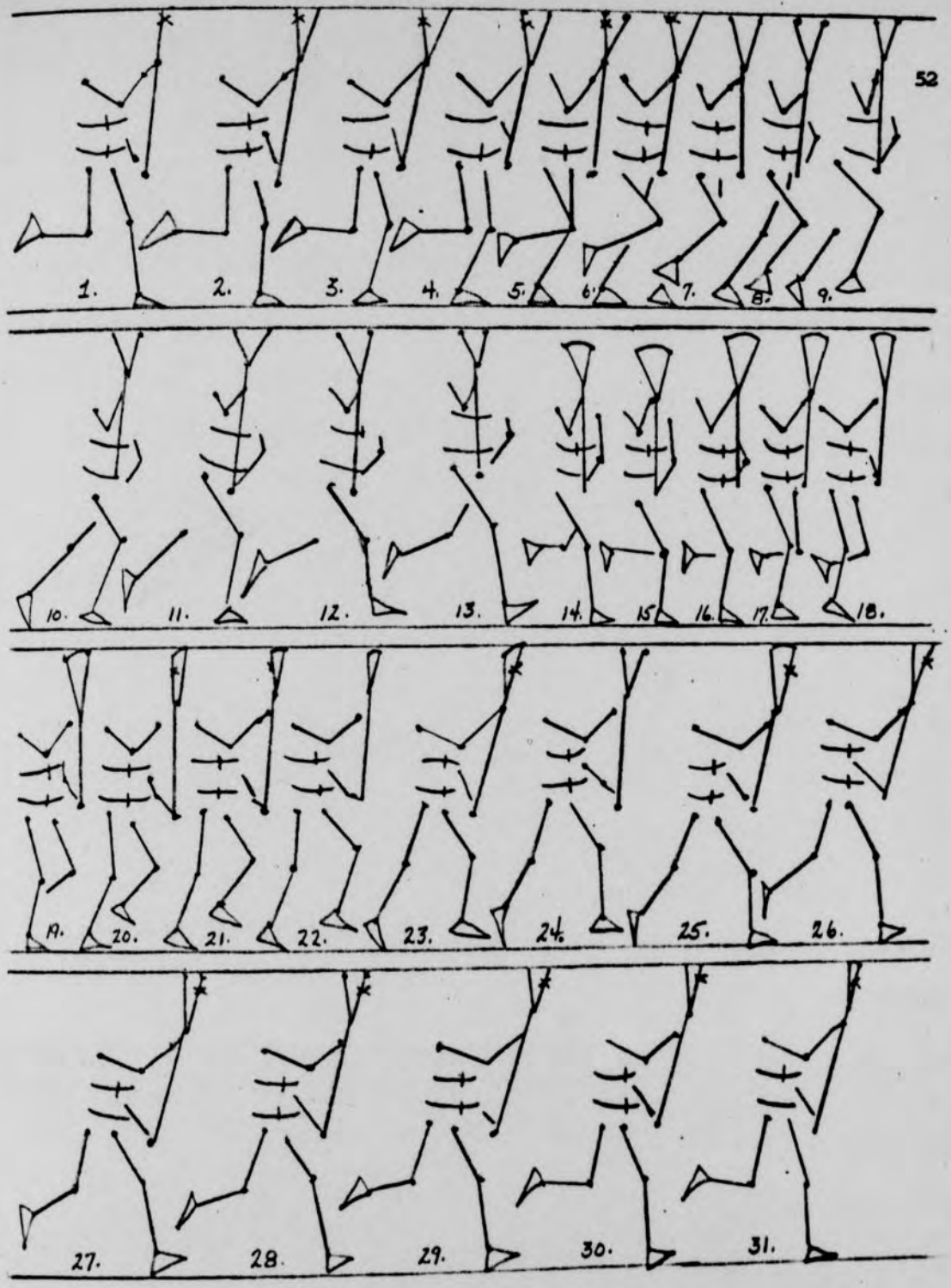

FIGURE 11

A SEQUENCE OF FRAMES OF THE BEGINNER
PERFORMING THE CRADLE AS TAKEN
WITH CAMERA TWO